Steelhead Habitat Assessment For The San Pedro Creek Watershed

Hagar Environmental Science

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Prepared for:

San Pedro Creek Watershed Coalition
c/o Christine Chan, Projects Coordinator
122 Hilton Lane #3
Pacifica, California 94044

Prepared by:

Hagar Environmental Science
6523 Claremont Avenue
Richmond, CA 94805

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APPENDIX A

1.0 Summary

This report describes a survey conducted by Hagar Environmental Science (HES) to assess existing habitat conditions for steelhead within the San Pedro Creek Watershed and identify potentially limiting factors, needs for habitat protection, and potential for habitat enhancement.

The habitat survey included detailed mapping of representative stream reaches, identification and reconnaissance level evaluation of potential steelhead migration obstacles, and recording visual observations of steelhead present in each survey area. Surveys were conducted on September 4-6 and October 18-19, 2001, covering 1.96 miles of the mainstem, 1.36 miles of the Middle Fork, 0.50 miles of the South Fork and 0.32 miles of the Sanchez Fork.

Suitable habitat for steelhead exists primarily in the Mainstem and Middle Fork. Suitable habitat for spawning is located throughout the Mainstem and Middle Fork but the best quality spawning habitat appears to be in the Middle Fork. This is supported by visual observation of numerous young-of-year steelhead/rainbow trout in the Middle Fork suggesting also that the Middle Fork provides good conditions for rearing steelhead in their first year of life. The Mainstem provides the best conditions for rearing steelhead to smolt size and for supporting non-anadromous life histories, however, steelhead using the Mainstem are more vulnerable to potential water quality degradation, siltation, sedimentation, and disturbance than those in the Middle Fork.

Although steelhead were present in the South Fork, their abundance appeared extremely low based on visual counts. Suitable spawning sites were very scarce in the South Fork. Only the lower reach had any pools and pools made up only 7% of surveyed length of the lower section.

The Sanchez Branch was very small and somewhat degraded due to the presence of high levels of silt and fine sediment, anthropogenic debris, and a significant obstacle to steelhead migration. There is a lot of existing and ongoing residential development in the watershed. Pool frequency was very low in Sanchez Branch but in spite of its small size and degraded habitat conditions, there were a few trout in it. All trout observed were less than 4 inches in length and were observed both downstream and upstream of the first perched culvert, indicating they may be the progeny of non-anadromous resident trout.

The Shamrock Branch appears to have little or no potential to support steelhead/rainbow trout. The stream channel has been placed in a culvert from near the confluence with the mainstem and running under a residential neighborhood and Linda Mar School. Upstream of Linda Mar School, the stream channel is extremely small and overgrown by dense growths of willow, blackberry and other riparian species. The watershed outside the immediate stream channel consists mostly of grassy fields on the valley floor and scrub on the side slopes. There is little indication of a permanent stream in the drainage, either historically or at present, and the drainage bears more resemblance to a straightened and overgrown drainage ditch.

The most significant factors limiting steelhead in the San Pedro watershed, or with high potential to do so, include fish passage at Mainstem road crossings, low base flows, mobilization and accumulation of fine sediments in the Mainstem, deterioration of water quality, disturbance, and exploitation. In addition to their impacts on steelhead biology, some of these factors present issues of regulatory significance in terms of their potential to result in "take" under the Endangered Species Act.

The four mainstem migration obstacles and the obstacle in the Middle Fork all limit, to varying degrees, the ability of adult steelhead to access spawning areas and the free movement of juvenile steelhead within rearing areas. It is recommended that these be evaluated to determine under what flow conditions passage guidelines are met and how often those conditions are expected to occur at each site. This will enable prioritization of enhancement projects and those with the shortest passable periods should be targeted for modification. The most severe problems are expected at Capistrano Drive, followed in order by Linda Mar Boulevard, Oddstad Boulevard, and Adobe Drive but this should be verified by more detailed evaluation.

Based on the existing information, temperature conditions appear not to be a factor limiting steelhead production in the watershed, although there may be some thermal loading from the North Fork that could be problematic, particularly during the July-August period. Detailed temperature monitoring using simple automated recorders is recommended to verify that temperature is not a concern.

Natural low stream flow levels in the small sub-watersheds limit steelhead production in the tributaries. Any increase in diversion of stream flows has the potential to further limit steelhead populations in the watershed. A diversion in the South Fork operated by the North Coast County Water District has been operational at times in the past and has the potential to influence habitat conditions below the diversion. The degree of riparian diversion from the Mainstem is unknown but several pump installations were noted during the habitat assessment.

Habitat surveys indicated that shelter conditions in those reaches that are suitable for steelhead (primarily in the Mainstem and Middle Fork) are consistent with good steelhead production in comparable streams. Although steelhead population assessment was not conducted as part of this survey, visual observations and results of previous surveys indicate that production of steelhead in San Pedro Creek is similar to other comparable streams in the region. It would be of interest to compare past abundance estimates with current density using a more rigorous method such as quantitative electrofishing.

Although the North Fork, Shamrock Branch, and Sanchez Branch are not considered to have significant potential to support steelhead, these watersheds contribute to water quality, sediment, and flow conditions in the Mainstem and thereby have significant potential to impact steelhead populations. Projects to improve water quality, minimize mobilization of sediment, reduce peak flows, and enhance baseflows should be undertaken in these watersheds to benefit steelhead using the Mainstem.

Considering the proximity of the creek to large numbers of people, there is a potential for harm to steelhead through disruption of feeding and spawning activity, destruction of eggs and fry within the gravel, harassment, and illegal capture. The level of angler use, legal or illegal, is not consistently monitored and is unknown. It is recommended that the stream be buffered from human disturbance wherever possible through agreements, easements, and acquisitions. There has been some encroachment on the creek without full recognition of the potential amenities of natural stream corridors and liabilities of development in flood prone areas. This condition should be corrected wherever an opportunity presents itself.

2.0 Background and Objectives

The San Pedro Creek Watershed Coalition (SPCWC) is dedicated to protecting, enhancing, and maintaining the health of San Pedro Creek and its watershed. The SPCWC has developed a Watershed Plan and undertakes a variety of monitoring, restoration, educational, and promotional activities within the watershed. The SPCWC has developed a set of goals and objectives that include assessment of habitat conditions for native aquatic species and restoration of populations of native fauna in the watershed; in particular, restoration of the steelhead fishery of San Pedro Creek.

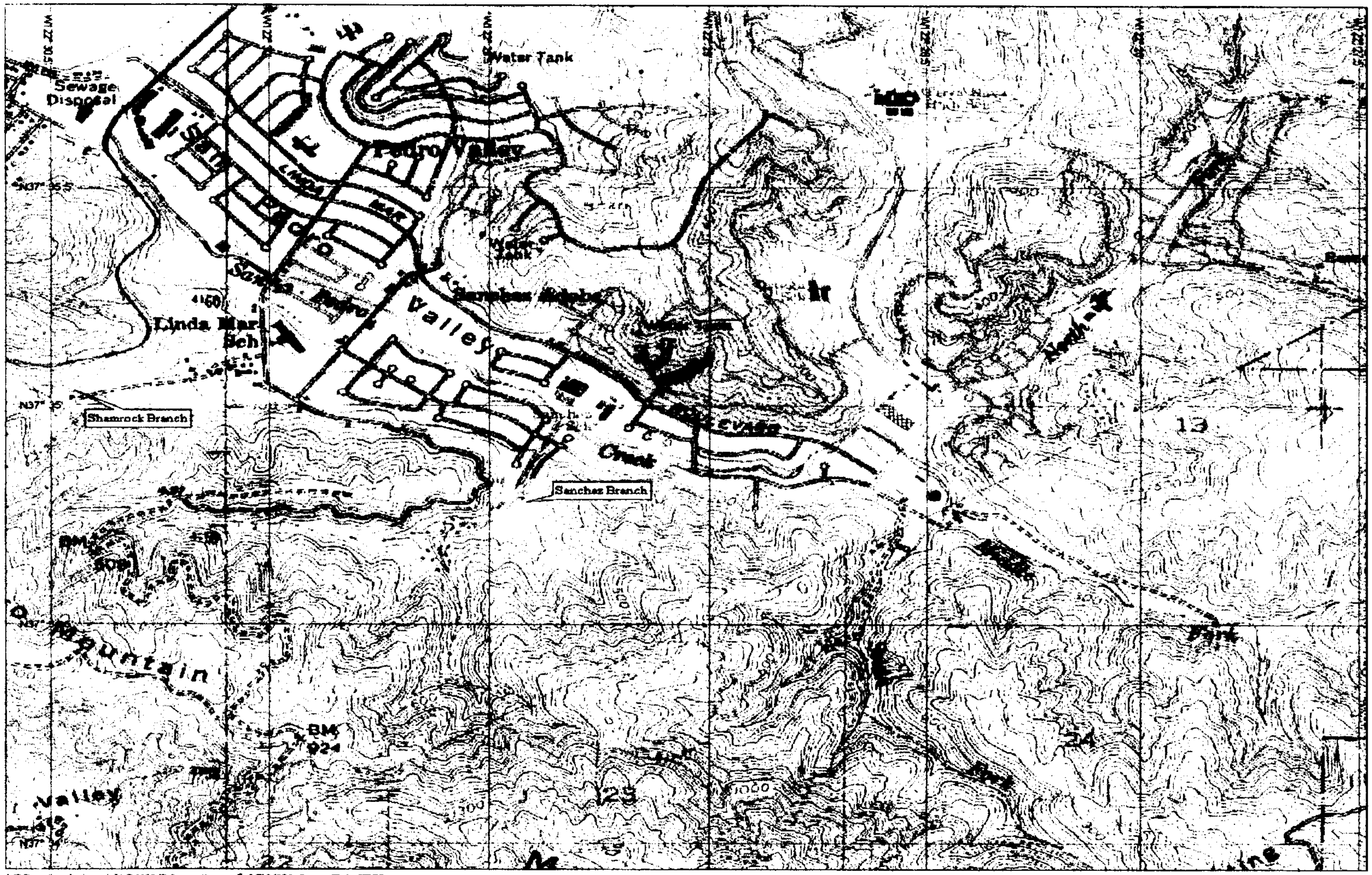
This report describes a survey conducted by Hagar Environmental Science (HES) to assess existing habitat conditions for steelhead within the watershed and identify potentially limiting factors, needs for habitat protection, and potential for habitat enhancement. It is anticipated that this assessment will be used by the SPCWC in setting priorities for adaptive management, educational activities, or restoration projects by considering the practicality of addressing key limiting factors and weighing the relative benefits to be expected.

2.1 Existing Reports and Data

The San Pedro Creek watershed, at about 8.2 square miles, is a relatively small coastal drainage (Figure 1). For its small size, the watershed encompasses a wide variety of watershed conditions ranging from relatively dense residential and commercial development along the mainstem, dense residential development and altered drainage channels on the northern side of the basin, and relatively undisturbed parklands and lands managed for water supply production on the Middle Fork and South Fork.

Stream habitat and steelhead populations have undoubtedly been influenced by human activities in the watershed, particularly in the last century (Collins et. al 2001). Native people inhabiting the watershed prior to European settlement used fires to manage habitat and the pre-European landscape of San Pedro valley appear to have contained much more grassland than is present today. Native people likely used steelhead as a food source as did the grizzly bears that inhabited the watershed before 1859.

Prior to the mid-1800s there was a large seasonal wetland and lagoon occupying the lower reaches of San Pedro Creek. Early maps show a large willow thicket (sausal) in the area east of what is now Linda Mar Shopping Center and bordered by San Pedro Terrace Road, Adobe Drive, and Arguello Boulevard West of the willow thicket was a seasonal lagoon (Collins et al. 2001). Downstream of about where Adobe Drive now crosses the Creek, it is likely that the stream channel was indistinct through the willow thicket and may have provided little more than isolated pools during the dry season. The seasonal lagoon probably functioned similar to other lagoons along the Central Coast, with the lagoon forming during the dry season behind a sandbar at the mouth and draining during the wet season when streamflow was high enough to breach the sandbar. These lagoons can provide excellent rearing habitat for steelhead, often providing a sufficiently rich food supply that juvenile steelhead can reach smolt size in a single growing season rather than taking two seasons or more as can occur in less productive stream habitats.



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 544 ft Scale: 1 : 19,200 Detail: 13-3 Datum: WGS84

Figure 1. San Pedro Creek Watershed with Survey Reaches

More intensive agriculture was practiced beginning in 1850s and 1860s and sometime prior to 1928 the willow thicket was entirely removed and San Pedro Creek was confined to an aligned channel through the area (Collins et al. 2001). The lagoon (Lake Mathilda) may have been encroached by agriculture during this period and by 1955, the former lagoon was overlain by the Linda Mar shopping center and other suburban development. Although rearing habitat in the lagoon would have been lost, there is presently rearing habitat in the realigned section of San Pedro Creek and passage for migrating steelhead may have been somewhat enhanced compared to the former willow thicket.

Suburban development, begun in earnest during the early 1950s, resulted in placement of much of the North Fork in underground culvert, new bridges on the mainstem and dense residential development of much of the valley floor northern hill slopes (Collins et al. 2001).

2.2 Habitat Assessment Methods

The goal of the habitat assessment is to determine where in the watershed there is habitat for steelhead and to identify factors that may limit steelhead use of the watershed. The survey covered the mainstem, Middle Fork, South Fork, Sanchez branch, and Shamrock branch. The habitat assessment involved a walking survey of streams in the watershed where access was available. Since most of the streams draining the north side of the watershed have been culverted and much of the drainage area has been developed, no surveys were conducted there.

The habitat survey included detailed mapping of representative stream reaches in accordance with the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998). This is a widely accepted, repeatable, and quantifiable method. Habitat surveys were conducted on September 4-6 and October 18-19, 2001. Habitat mapping was conducted in 1.96 miles of the mainstem, 1.36 miles of the Middle Fork, 0.50 miles of the South Fork and 0.32 miles of the Sanchez Fork. Habitat mapping was conducted using the following protocols and modifications:

- Habitat typing was conducted at a Level IV classification using a ten percent sampling protocol (Flosi et al. 1998). Given budget constraints, this provides an acceptable level of detail in terms of habitat description while allowing for coverage of a greater length of stream reaches in the watershed. It was considered important to survey as much of the watershed as possible to identify important site specific factors (e.g., passage obstacles, localized sources of sediment or water quality problems, diversions, and other localized factors).

- In each sample reach all habitat units were identified by type and length measured. First encounters for each habitat type, and a randomly selected 10% sample were characterized in full detail.

- Maximum depth, pool tail crest depth, and pool tail embeddedness were recorded for every pool encountered. In addition to other characteristics, pools were defined as having a residual maximum depth of 1 foot or more.

- Canopy density was recorded for every third habitat unit.

- Bank composition and vegetation estimates are standard components of the California Salmonid Stream Habitat assessment method. The SPCWC has already conducted detailed geomorphic and riparian vegetation assessments that provide greater information value and greater utility in identifying sediment production problems and candidate sites for re-vegetation. To streamline data collection, bank composition and vegetation parameters were omitted from the habitat assessment.

Although fish population surveys are not usually part of the habitat assessment, visual observations of fish can be easily incorporated into the habitat assessment and this documentation can provide valuable information to support conclusions concerning habitat quality and suitability. The habitat assessment was completed during the late summer when visibility is best and conditions are likely to be most limiting for rearing parr.

As part of the habitat assessment, potential obstacles to migration were identified, located by GPS, photo documented and described with reference to species specific criteria in the scientific literature for passage at both natural and constructed obstacles (Bjornn and Reiser 1991; NMFS 2000; WDFW 1999).

The results of habitat surveys and fish sampling were evaluated to identify key factors that potentially limit fish populations in the watershed. Several key factors were considered in determining potentially limiting factors and potential for improvement including the frequency and quality of summer pool habitat, substrate conditions, bank and canopy conditions, stream temperature, and obstacles to fish movement. The importance of these factors is discussed briefly as follows:

Summer pool habitat

The habitat inventory assessed the amount and quality of pool habitat in each reach. Pool habitat is important because pools provide habitat during the summer low flow period and during periodic droughts. Older age classes of steelhead/rainbow trout rely heavily on pool habitat during stream residence and pools can provide essential holding cover for adult steelhead when they enter streams for spawning and before they return to the ocean. Deeper pools with good cover characteristics provide very important habitat. Although adult resident trout and second year steelhead parr may inhabit pools with mean depths in the range of 0.5 to 1.5 feet in small streams, they generally occur at greater densities in streams with more pools in the 1.5 to 2.5 foot mean depth range or deeper. Excessive fine sediments in a stream may result in loss of pool depth and cover components. The extent and quality of pool habitat can be greatly influenced by the health of riparian vegetation (see below). Tree branches and tree trunks occasionally fall into streams due to aging or erosion. This material (large woody debris) contributes to pool formation and instream cover for fish. In many developed areas, large woody debris is actively removed from stream channels to prevent flooding and bank erosion, resulting in fewer pools and less cover for fish.

Substrate condition

Substrate conditions influence production of aquatic invertebrates important in the aquatic food chain. Steelhead/rainbow trout also rely on relatively loose, clean gravel substrate with low amounts of fine sediments for reproduction. Larger substrate such as cobbles

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and boulders can provide hiding areas for juveniles and may be particularly important during winter high flow conditions. Fine sediments (silt and sand) present in excessive amounts fill spaces between the larger substrate elements and reduce its ability to support invertebrate production, spawning, and escape cover. Excessive amounts of fine sediment may also fill in pools and other deep areas and reduce their utility as habitat for adult fish. There are several methods to measure and evaluate substrate conditions. The California Salmonid Stream Habitat Assessment Manuel uses estimation of dominant and subdominant substrate size classes (silt, sand, gravel, cobble, etc.), and estimation of cobble embeddedness. Cobble embeddedness is assessed by observing the average proportion of individual cobble size substrate that is embedded within finer material. Fish density, particularly for juvenile trout and salmon, is generally reduced as embeddedness increases. Steelhead/rainbow trout appear to be less sensitive than some other salmonid species. Young-of-year fish are particularly sensitive during winter and can be impacted at embeddedness levels greater than 5-10%. Older juveniles during summer may tolerate embeddedness levels of 30-50% without significant impacts on population density. Embeddedness can change as a result of seasonal changes in flow conditions and can be altered at steelhead nest sites by the nest building activities of the female.

Bank and Canopy

Trees and shrubs on the stream bank are intricately linked to the aquatic environment and influence it in many ways. Vegetation provides shade and moderates temperature conditions. This vegetation also serves as an important source of nutrients to the stream, both through direct input of organic matter and as a source of terrestrial insects. Aquatic productivity can be inhibited under conditions of continuous closed canopy, and the ideal condition is a moderately dense canopy (55-85%) with occasional small openings. The roots of riparian species such as alder, willow, sycamore, and redwood form networks that strengthen and retain the bank and lead to formation of scour pools and undercut banks that provide excellent instream cover for fish. As these trees age they may eventually fall into the stream and their trunks and branches alter flow patterns and provide hard structures resulting in scouring of pools. Terrestrial vegetation hanging over the stream bank also can provide useful overhead cover for fish.

Temperature

Temperature determines the distribution of many native fish species and rainbow trout in particular. Stream temperature generally fluctuates on a daily basis in parallel with air temperature and generally reaches maximum levels in Central California coastal streams in July and August. Temperature becomes lethal for trout as it approaches and exceeds about 25°C (77°F). Though there is much variation, temperatures below 18°C (64°F) are generally regarded as optimum for rearing trout and temperatures up to 21°C (70°F) may be suitable if food is sufficiently abundant. For general purposes, in Central California coastal streams, a reach can be considered capable of supporting a coldwater fish community (i.e., trout) if temperature only rarely exceeds 18°C (20% of the time or less) and never exceeds 21°C. Reaches where stream temperature exceeds 21°C but not for more than 10% of the time and never exceeds 24°C were considered sub-optimal but potential coldwater habitat. If temperature exceeds 21°C for more than 10% of the time or ever exceeds 24°C, the reach would be considered warmwater habitat. These are somewhat conservative criteria as exceptions are known to occur.

Obstacles to fish movement

Maintenance of healthy fish populations often requires that fish be able to move from one place to another within the watershed. This movement may occur for several reasons including: dispersal of young fish after hatching; re-colonization of habitat after droughts, floods, or other extreme events; seasonal movement of adult fish from rearing areas to spawning areas; and, change in habitat requirements as fish mature. Juvenile trout prefer shallower glide and riffle areas in or near relatively swift current but as they mature they move to deeper habitats. This may involve downstream dispersal as fish mature. The most critical aspect of migration in most Central California coastal streams involves the ability of adult steelhead to enter the streams and easily access spawning and rearing habitat in the upper reaches.

Extreme events may eliminate fish from sections of stream. During droughts some sections may go dry. Fish may also move downstream during extreme high flows. Episodes of poor water quality conditions may eliminate fish from a section of stream. In these cases dispersal from refuge areas is required to re-populate the stream. If the only refuge areas are downstream, migration obstacles may result in failure of re-colonization and loss of fish populations from otherwise suitable habitat upstream.

3.0 Survey Results

Results of the assessment are presented in the following sections by sub-watershed area. Dividing the watershed into sub-watershed areas is a useful way to organize and summarize the detailed information collected in the assessment. As discussed previously, sub-watershed areas in the San Pedro Creek watershed vary greatly in terms of elevation, gradient, and surrounding land uses and these influence channel and habitat characteristics. There is no discussion of the North Fork since habitat there has been so altered by residential development that it is considered to have no potential to support steelhead.

Average discharge during the survey was estimated at 1 to 1.5 cubic feet per second (cfs) in the mainstem, 0 to .25 in the Middle Fork, 1.5 to 2.5 cfs in the South Fork, and .15 to .30 in Sanchez Branch and Shamrock Branch, respectively (Table 1). Estimated discharge may have been influenced by the time of survey since most of the tributaries were surveyed in early September but the mainstem and Shamrock Branch were surveyed in mid-October. The South Fork appeared to contribute a substantial proportion of the late summer flow to the mainstem. Mean wetted width was generally consistent with differences in drainage area (Table 1).

3.1 San Pedro Creek Mainstem

Three reaches of the mainstem were surveyed. The first extended from Highway 1 to about one quarter mile upstream of Adobe Drive, the second from Sanchez School to the North Fork confluence, and the third from the North Fork confluence to the South Fork.

Table 1. San Pedro Watershed Fish Habitat Summary

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Length surveyed (feet)	6634	3737	1948	4816	411	764	1872	1692	89
Average of mean width (feet)	9.6	10.5	7.1	4.6	3.5	5.2	5.0	4.7	2.0
Average of estimated discharge (cfs)	1.29	1.50	1.17	0.18	0.03	2.50	1.63	0.30	0.15
Number of units									
Flatwater	39	20	14	33	5	9	7	18	0
Pool	48	30	12	14	3	4	1	4	1
Riffle	52	17	15	34	8	11	4	14	2
Percentage by length									
Flatwater	31%	49%	44%	66%	24%	55%	92%	68%	0%
Pool	41%	35%	16%	7%	13%	7%	0%	5%	13%
Riffle	28%	16%	40%	27%	63%	39%	8%	27%	87%

Notes: cfs: cubic feet per second

Pools were relatively frequent and extensive in the two mainstem reaches, comprising 35% to 41% of the stream length below the North Fork (Table 1, Figure 2). Upstream of the North Fork, flatwater and riffle habitat became the predominant types with pools making up only 16% of the reach length. Pool depth was also substantially greater in the mainstem where the lower reach had 43% of the pools with mean depths greater than 1 foot and 38% of pools with maximum depths greater than 2 feet (Table 2, Figures 3 and 4). The upper mainstem reach had even deeper pools with 61% having mean depths of more than 1 foot and 54% having maximum depths of more than 2 feet. In contrast only 8% of pools in the mainstem upstream of the north fork had pools with mean depth greater than 1 foot and none had maximum depths greater than 2 feet.

Visual observations of trout in the mainstem indicated relatively high abundance of young-of-year steelhead (4 inches or less in length) in the middle and lower reaches (Table 3). Very low abundance of these fish was observed in the reach between the North and South forks. Older steelhead (greater than 4 inches in length) were also relatively abundant in the middle and lower reaches though much less abundant than young-of-year. Young-of-year steelhead were distributed fairly evenly across all depth classes. In other words, the proportion of trout encountered within different depth classes was roughly the same as the proportion of pools within each class indicating a lack of selection for depth (Table 4). On the other hand, fish greater than 4 inches were found disproportionately in deeper pools, particularly in the upper mainstem reach where 76% of the larger trout were found in pools with maximum depths greater than 2.5 feet, even though such pools only accounted for 26% of the total pool length within the reach. In the lower mainstem reach, larger trout appeared to avoid only the shallowest pools, those with maximum depth of 1.5 feet or less. They were found roughly in proportion to availability for other depth classes (Table 5). Although visual estimates are not precise, they are useful as an index of abundance. In interpreting these results it is likely that older fish are less visible than younger fish due to their preference for deeper water and greater orientation to cover. In particular, they are probably harder to see in deeper water or where there is more cover.

The proportion of each habitat unit that was influenced by some type of shelter was estimated as a percentage of the total surface area of the unit. A shelter complexity rating of low, medium, or high was also estimated for each habitat unit based on the areal coverage and structural complexity of cover present. Presence of cover is most important in the pool and flatwater habitats used most frequently by trout and is not as important in riffle habitats. Percent coverage was lowest in the mainstem and higher in the tributaries. This would be expected since much of the cover is provided by features associated with the bank and the wider mainstem habitats had a greater area in the center of the channel that was not influenced by the banks. Shelter complexity was generally medium to low in the mainstem reaches (Table 6). Percent shelter coverage averaged 23%, 24%, and 26% in the lower, middle and upper mainstem, respectively. In pool habitats, percent shelter coverage averaged 31%, 23% and 33%, respectively and in flatwater habitats, percentages were 28%, 34% and 27%, respectively. These are consistent with shelter coverages in streams with good steelhead production.

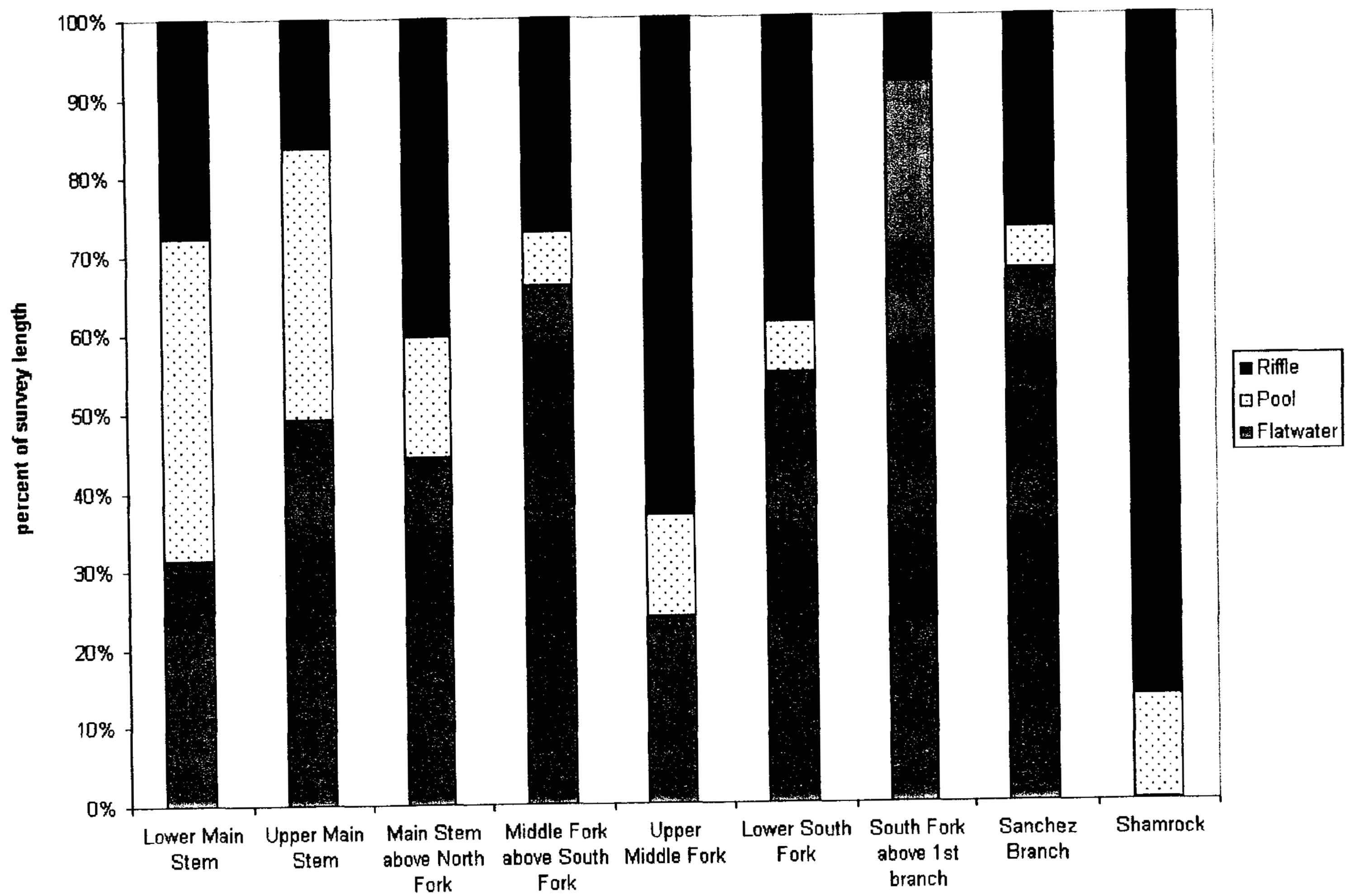

Figure 2. Fish Habitat Type by Reach

Table 2. San Pedro Watershed Pool Depth Summary

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Total number of pools	47	28	12	13	3	4	1	4	1
Length Surveyed (feet)	6,634	3,737	1,948	4,816	411	764	1872	1,692	89
Average Pool Spacing (ft.)	141	133	162	370	137	191	1872	423	89
Average Pool Depth (feet)									
0.0 – 0.5	4%	4%	17%	46%	33%	0%	0%	25%	100%
0.6 – 1.0	53%	36%	75%	54%	67%	25%	100%	25%	0%
1.1 – 1.5	30%	36%	8%	0%	0%	75%	0%	25%	0%
1.6 – 2.0	11%	25%	0%	0%	0%	0%	0%	25%	0%
2.1 – 2.5	2%	0%	0%	0%	0%	0%	0%	0%	0%
Maximum Pool Depth (feet)									
0.0 – 1.0	0%	0%	0%	0%	0%	0%	0%	0%	100%
1.1 – 1.5	21%	21%	83%	85%	67%	0%	0%	25%	0%
1.6 – 2.0	40%	25%	17%	15%	33%	100%	100%	25%	0%
2.1 – 2.5	15%	14%	0%	0%	0%	0%	0%	25%	0%
2.6 – 3.0	11%	29%	0%	0%	0%	0%	0%	25%	0%
3.1 – 3.5	11%	4%	0%	0%	0%	0%	0%	0%	0%
3.6 – 4.0	2%	7%	0%	0%	0%	0%	0%	0%	0%

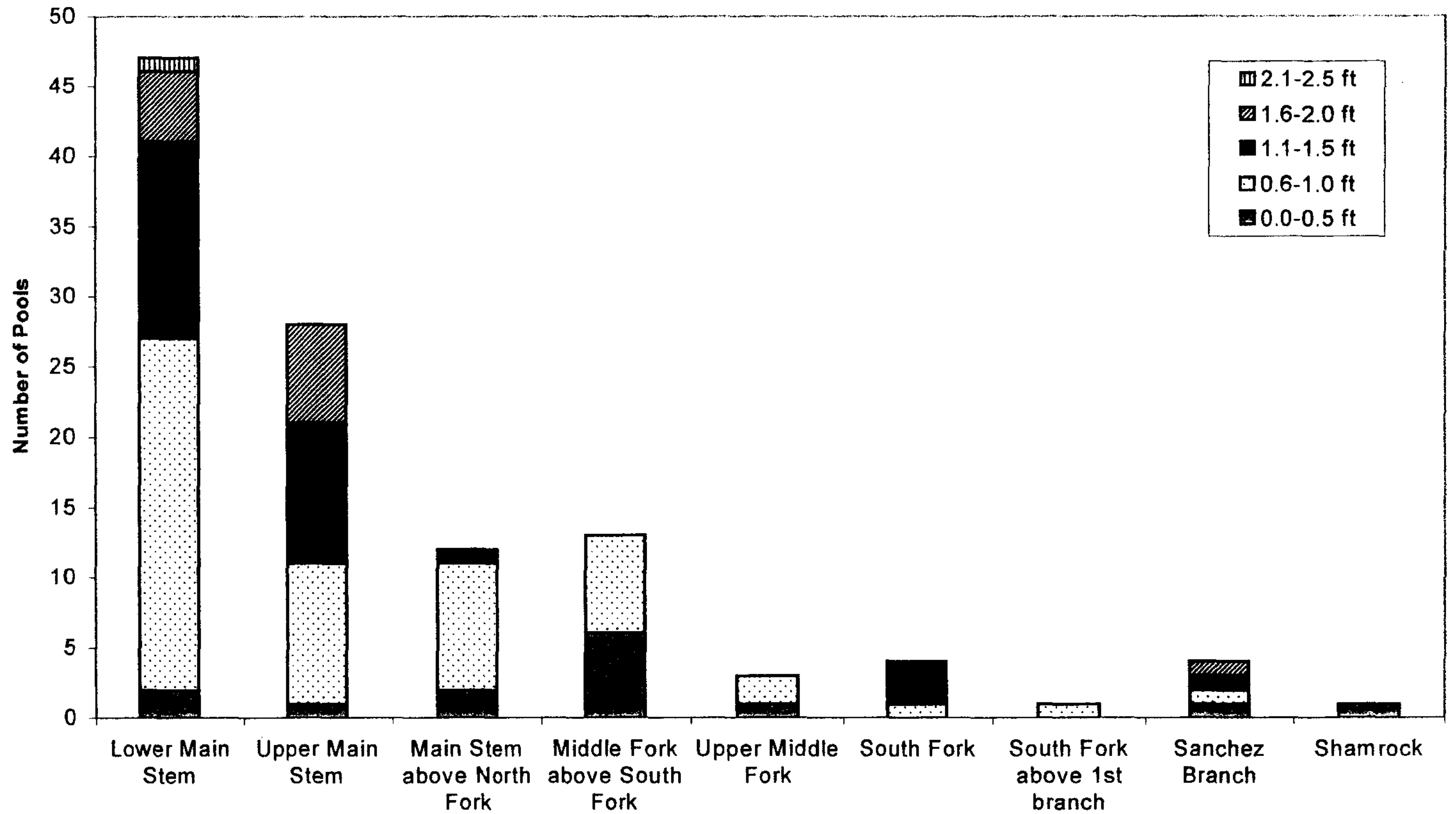

Figure 3. Average Pool Depth by Reach

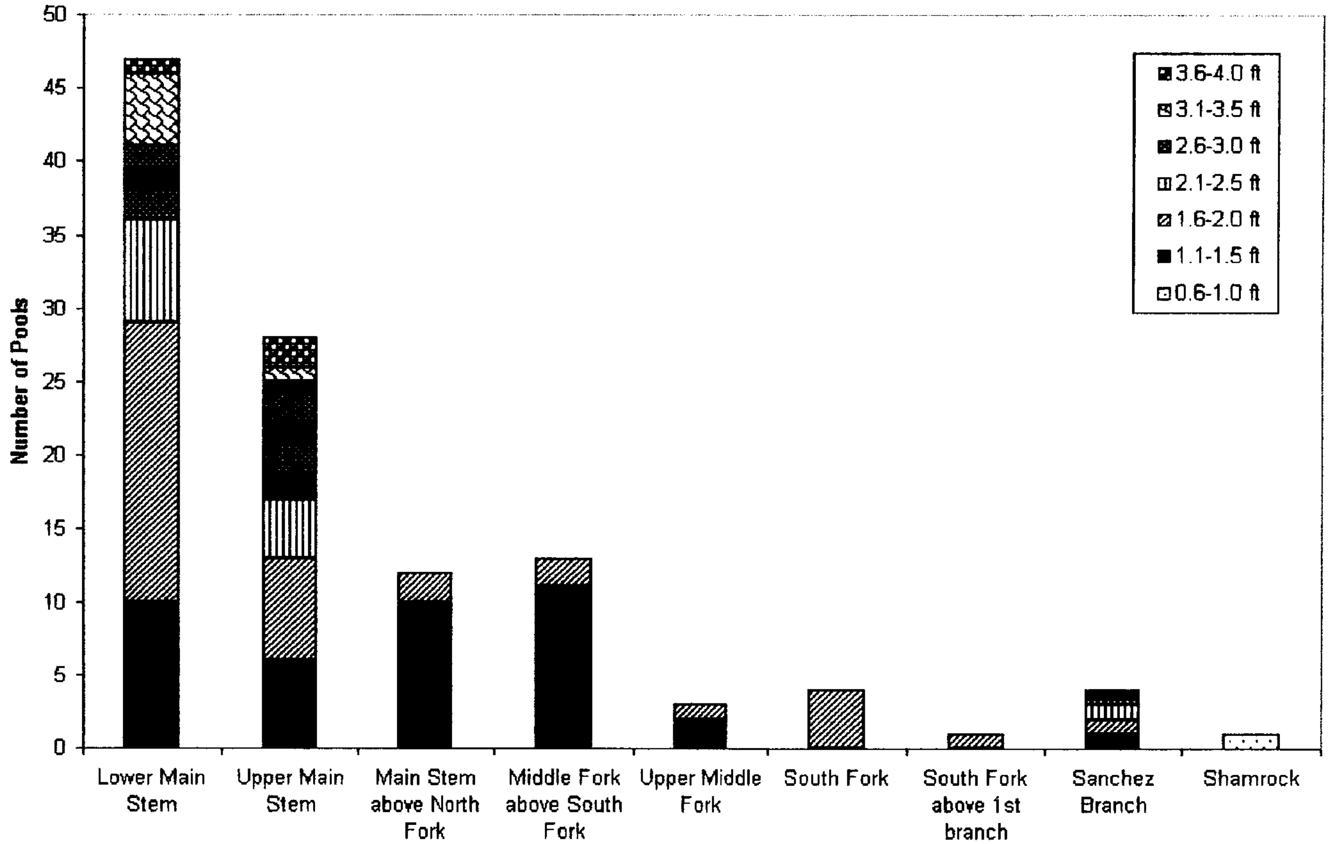

Figure 4. Maximum Pool Depth by Reach

Table 3. San Pedro Watershed Trout Observed during Habitat Inventory

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Number trout 4" or less (TL in.)	212	225	10	203	8	3	2	15	0
Number trout over 4" (TL in.)	17	27	0	5	1	0	1	0	0
Sum of Habitat Length (feet)	6,634	3,737	1,948	4,816	411	764	1872	1,692	89
Trout per 100 feet (<4")	3.20	6.02	0.51	4.22	1.95	0.39	0.11	0.89	0.00
Trout per 100 feet (>4")	0.26	0.72	0.00	0.10	0.24	0.00	0.05	0.00	0.00

Notes: TL: total length
in.: inches

Table 4. Depth Selection by Young-of-Year Trout (less than 4 inches total length)

	Lower Main Stem		Upper Main Stem		Mainstem above North Fork		Middle Fork above South Fork		Upper Middle Fork	
Maximum Depth Class	**% of Habitat**	**% of Trout**	**% of Habitat**	**% of Trout**	**% of Habitat**	**% of Trout**	**% of Habitat**	**% of Trout**	**% of Habitat**	**% of Trout**
0.0-0.5 feet	6%	0%	2%	0%	17%	0%	40%	5%	78%	13%
0.6-1.0 feet	8%	1%	12%	2%	38%	100%	37%	61%	0%	0%
1.1-1.5 feet	18%	4%	29%	23%	37%	0%	21%	35%	16%	88%
1.6-2.0 feet	30%	44%	15%	17%	7%	0%	3%	0%	6%	0%
2.1-2.5 feet	21%	30%	13%	11%	0%	0%	0%	0%	0%	0%
2.6-3.0 feet	5%	5%	23%	38%	0%	0%	0%	0%	0%	0%
3.4-3.5 feet	10%	16%	3%	8%	0%	0%	0%	0%	0%	0%
3.6-4.0 feet	1%	0%	4%	1%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 5. Depth Selection by Yearling and Older Trout (more than 4 inches total length)

	Lower Main Stem		Upper Main Stem		Mainstem above North Fork		Middle Fork above South Fork		Upper Middle Fork	
Maximum Depth Class	**% of Habitat**	**% of Trout**	**% of Habitat**	**% of Trout**	**% of Habitat**	**% of Trout**	**% of Habitat**	**% of Trout**	**% of Habitat**	**% of Trout**
0.0-0.5 feet	6%	0%	2%	0%	17%	0%	40%	0%	78%	0%
0.6-1.0 feet	8%	0%	12%	0%	38%	0%	37%	20%	0%	0%
1.1-1.5 feet	18%	0%	29%	16%	37%	0%	21%	80%	16%	100%
1.6-2.0 feet	30%	65%	15%	4%	7%	0%	3%	0%	6%	0%
2.1-2.5 feet	21%	18%	13%	4%	0%	0%	0%	0%	0%	0%
2.6-3.0 feet	5%	6%	23%	52%	0%	0%	0%	0%	0%	0%
3.4-3.5 feet	10%	12%	3%	24%	0%	0%	0%	0%	0%	0%
3.6-4.0 feet	1%	0%	4%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	0%	100%	100%	100%	100%

Table 6. San Pedro Watershed Shelter Complexity

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Shelter Complexity	**Number of Habitat Units**								
High	1	1	2	3	1	2	4	1	
Medium	16	13	11	14	2	10	6	6	1
Low	8	4	4	7	4		2	6	2
None					2				
Average of % Unit with Shelter									
All Habitat Types	23%	24%	26%	28%	29%	34%	35%	22%	12%
Pools	31%	23%	33%	44%	42%	49%	60%	35%	31%
Flatwater	28%	34%	27%	30%	20%	30%	41%	21%	0%

The most frequently encountered cover types in the mainstem were undercut bank (a component in 63% of surveyed units), overhanging terrestrial vegetation (54% of units), substrate roughness (substrate particles of 5-inch median diameter or greater) (49% of units), small woody debris (42% of units), rooted aquatic vegetation (mostly watercress) (42% of units), and surface turbulence (34% of units). In terms of the areal extent of influence the most extensive cover types included undercut banks, rooted aquatic vegetation, and terrestrial vegetation but, substrate, small woody debris, and other components were also fairly extensive in some reaches (Figure 5 and Table 7). Rooted aquatic vegetation, mostly watercress, was an important shelter component only in the lower and middle mainstem (Figure 5).

Canopy was highly variable in the mainstem ranging from 0 to 95% in the lower reach and 5 to 100% in the upper reach (Table 8). The mainstem averages of 54% and 46% were considerably lower than the tributaries. This was related to a wider active channel in the mainstem and possibly, to greater disturbance in the more heavily residential areas bordering the mainstem. A more open canopy can enhance aquatic productivity and trout growth rates as long as associated temperature increase is not extreme. Given the generally cool marine climate of the watershed the level of canopy coverage observed is probably satisfactory.

The canopy was dominated by willow in the mainstem with lesser amounts of alder and dogwood. Alder became the dominant upstream of the North Fork.

In the lower mainstem, gravel was the dominant substrate in 67% of units surveyed and subdominant in an additional 25% (Table 9, Figure 6). Sand was the only other dominant substrate type (33% of units surveyed) and was subdominant in an additional 58% of units surveyed. Silt/clay and small cobble were each subdominant in 8% of the surveyed units. The middle mainstem had more sand than the lower section, with sand dominant in 53% of surveyed units. Gravel was the next most frequently encountered size class and was dominant in 35% of surveyed units. Silt/clay was present as a subdominant type in 29% of the surveyed units, the highest representation of silt/clay in all surveyed reaches in the watershed. During the survey, it was noted that flow from the North Fork was substantially more turbid than flow in the mainstem upstream of the North Fork confluence. The substrate was also notably more silty downstream of the North Fork confluence than upstream. This is especially significant since surveys were conducted during the lowest flow period when sediment mobilization and transport are expected to be minimal.

Gravel became the most frequently encountered substrate upstream from the North Fork, being dominant in 71% of surveyed habitat units. The major subdominant size class in this reach was small cobble.

It is instructive to look at substrate characteristics in riffle habitat types since riffles provide important habitat for production of aquatic invertebrates and salmonid spawning areas are typically located near the head of riffles. Although dominant substrate in all riffle habitats surveyed was either gravel, small cobble, or large cobble; the subdominant type varied greatly with location in the watershed (Table 10). In the lower mainstem reach sand was the subdominant in 75% of riffles surveyed. In the upper mainstem, sand was subdominant in 25% of units surveyed but upstream of the North Fork, sand did not occur as a subdominant in riffles. This is consistent with the overall decline in stream gradient from the tributaries to the mouth (Collins et al. 2001).

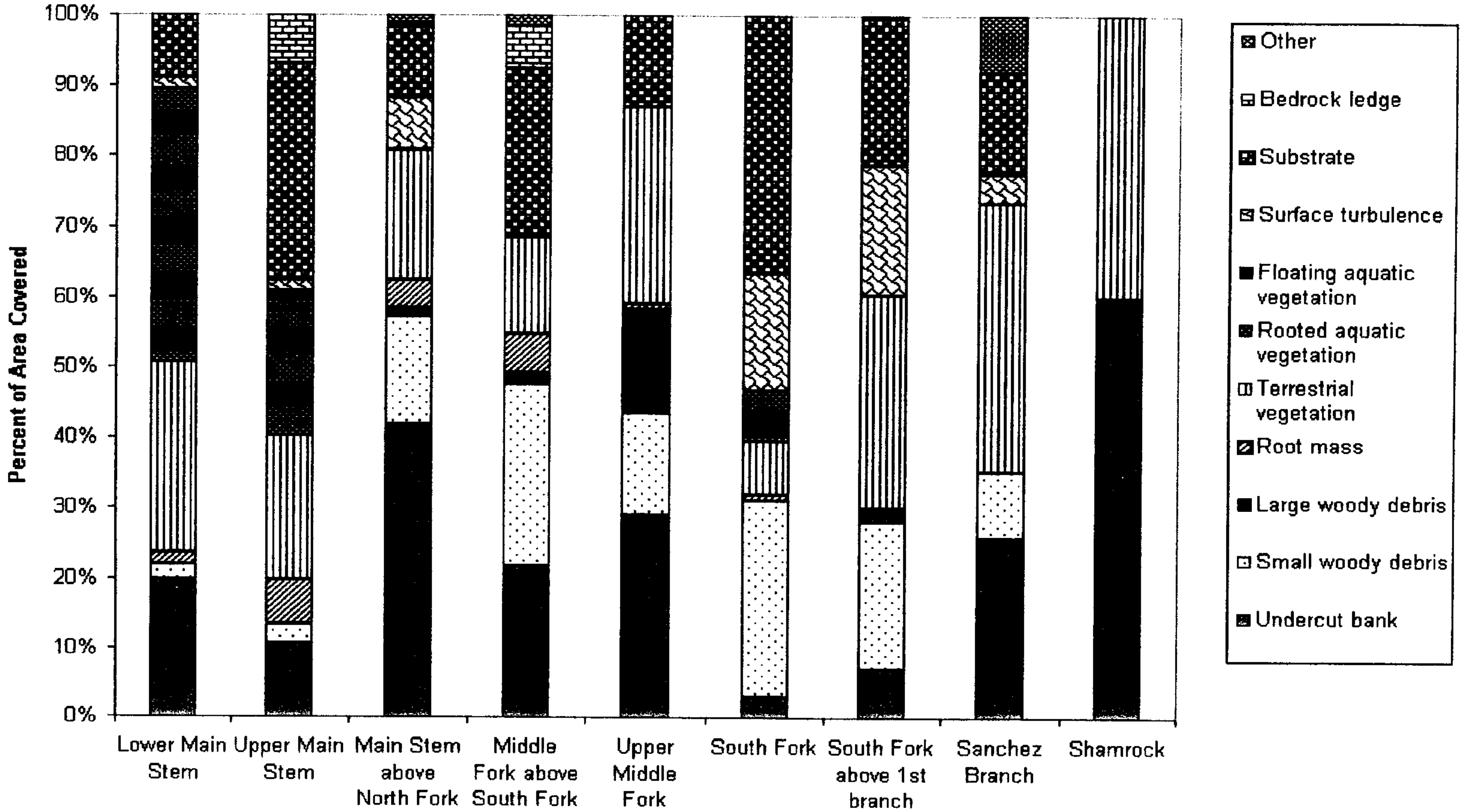

Figure 5. San Pedro Watershed Shelter Components

Table 7. San Pedro Watershed Shelter Components

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Frequency of Occurrence	**Number of Habitat Units**								
Undercut bank	16	8	13	11	4	6	3	6	1
Small woody debris	9	6	10	15	5	11	10	4	0
Large woody debris	1	0	2	3	2	1	1	0	0
Root mass	5	4	3	4	1	1	0	0	0
Terrestrial vegetation	17	10	5	14	3	7	10	8	1
Rooted aquatic vegetation	13	11	1	1	0	3	0	0	0
Floating aquatic vegetation	0	0	0	0	0	0	0	0	0
Surface turbulence	7	3	10	3	0	10	12	1	0
Substrate	11	9	9	19	5	9	11	7	
Bedrock ledge	1	4	1	7	1	1	1	0	0
Other	0	0	1	1	0	0	0	1	0
Total Surveyed Units	25	18	17	24	9	12	12	13	3
Areal Extent (percent)									
Undercut bank	20%	11%	42%	22%	29%	3%	7%	26%	60%
Small woody debris	2%	3%	15%	26%	15%	29%	21%	9%	0%
Large woody debris	0%	0%	1%	1%	15%	0%	2%	0%	0%
Root mass	2%	6%	4%	6%	1%	1%	0%	0%	0%
Terrestrial vegetation	27%	21%	18%	14%	28%	8%	30%	38%	40%
Rooted aquatic vegetation	39%	20%	0%	0%	0%	7%	0%	0%	0%
Floating aquatic vegetation	0%	0%	0%	0%	0%	0%	0%	0%	0%
Surface turbulence	2%	2%	7%	0%	0%	17%	18%	4%	0%
Substrate	9%	31%	10%	24%	13%	37%	21%	15%	0%
Bedrock ledge	0%	7%	1%	6%	0%	0%	0%	0%	0%
Other	0%	0%	1%	2%	0%	0%	0%	8%	0%

Table 8. San Pedro Watershed Canopy Characteristics

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Average canopy (%)	54%	46%	81%	87%	90%	81%	95%	88%	30%
Maximum canopy (%)	95%	100%	98%	98%	98%	98%	95%	98%	40%
Minimum total canopy (%)	0%	5%	35%	55%	80%	0%	95%	45%	20%
Dominant Canopy Species	**Number of Habitat Units**								
Willow	30	15	4	10	10	3		9	1
Alder	8	3	13	26		6	1	7	
Dogwood	4	3		4	1	4	2	1	
Eucalyptus	3	1	3			2			
Pine	2	2	1						1
Other	9	6	3	1		1		1	1
Total Surveyed Units	56	30	24	41	11	16	3	18	3
Subdominant Canopy Species	**Number of Habitat Units**								
Dogwood	10	6	2	8	10			6	
Willow	12	5	4	9	1	5		4	1
Eucalyptus	3		8			7	3		
Alder	5		4	10				1	
Elderberry		1	3	11		1		3	
Blackberry	7	5	2	1		2		1	
Herbaceous Plants	11	1							2
Other	8	9	1	1				3	
Total Surveyed Units	56	27	24	40	11	15	3	18	3

Table 9. San Pedro Watershed Substrate Characteristics

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Dominant Substrate	**Number of Habitat Units**								
Silt/clay		1	2			2		6	1
Sand	8	9	3	7	1	5	2	4	1
Gravel	16	6	12	16	7	3	8	1	
Small cobble				1	1	1	1	1	
Large cobble						1		2	1
Boulder		1					1		
Total Surveyed Units	24	17	17	24	9	12	12	14	3
Subdominant Substrate	**Number of Habitat Units**								
Silt/clay	2	5	2					1	
Sand	14	1	4	5		3	3	3	
Gravel	6	4	3	8	2	2		4	1
Small cobble	2	2	8	10	7	4	3	3	2
Large cobble		3				3	4	3	
Boulder		2		1			2		
Total Surveyed Units	24	17	17	24	9	12	12	14	3

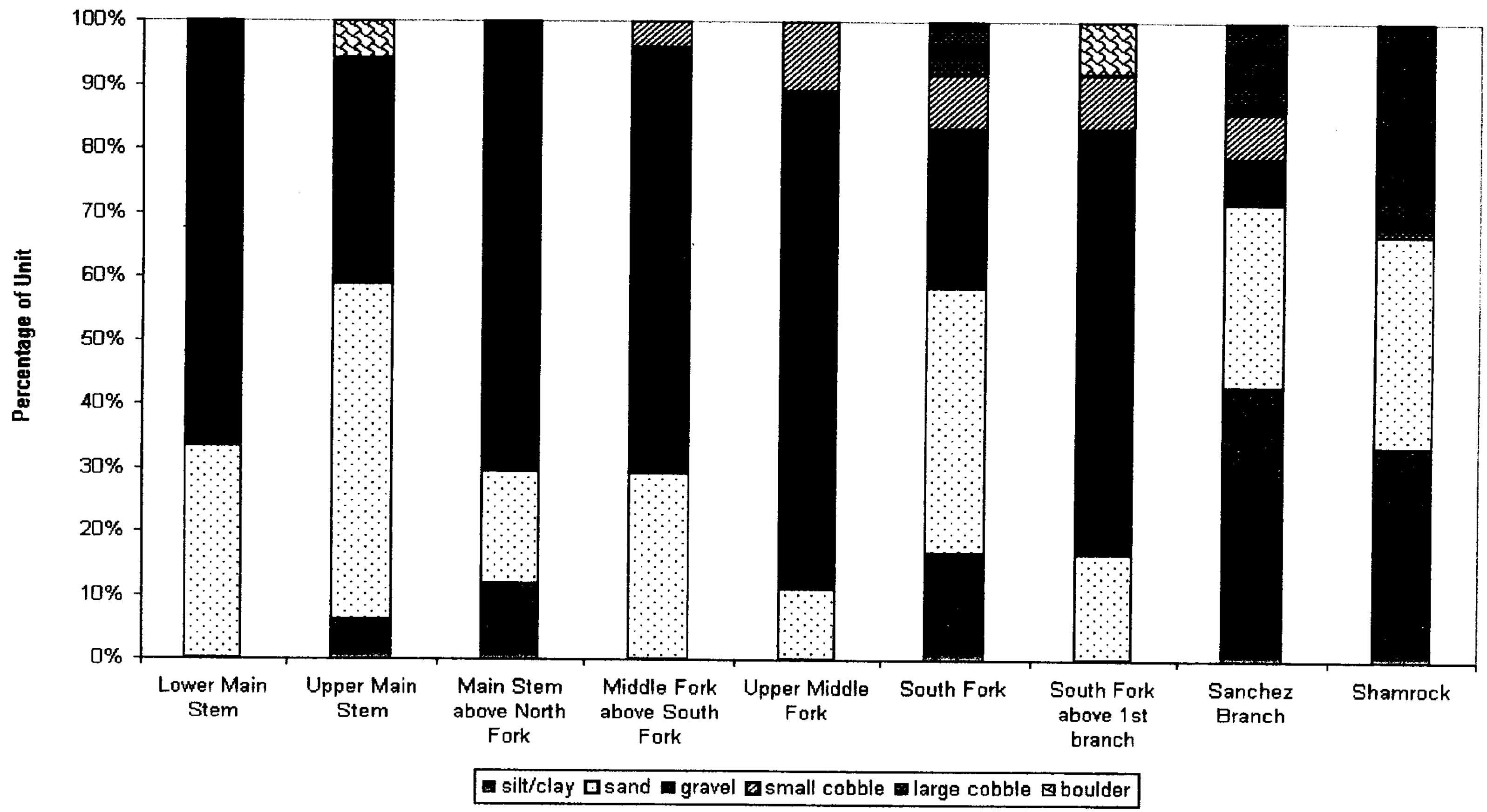

Figure 6. Dominant Substrate Characteristics

Table 10. San Pedro Watershed Riffle Substrate Characteristics

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Dominant Substrate	Number of Habitat Units								
Sand									1
Gravel	8	3	4	6	1	1	2	1	
Small cobble				1	1	1	1	1	
Large cobble						1		2	1
Boulder		1					1		
Total Surveyed Units	8	4	4	7	2	3	4	4	2
Subdominant Substrate	Number of Habitat Units								
Sand	6	1						1	
Gravel				1	1	1			1
Small cobble	2	2	4	5	1	1	2	2	1
Large cobble		1				1	1	1	
Boulder				1			1		
Total Surveyed Units	8	4	4	7	2	3	4	4	2

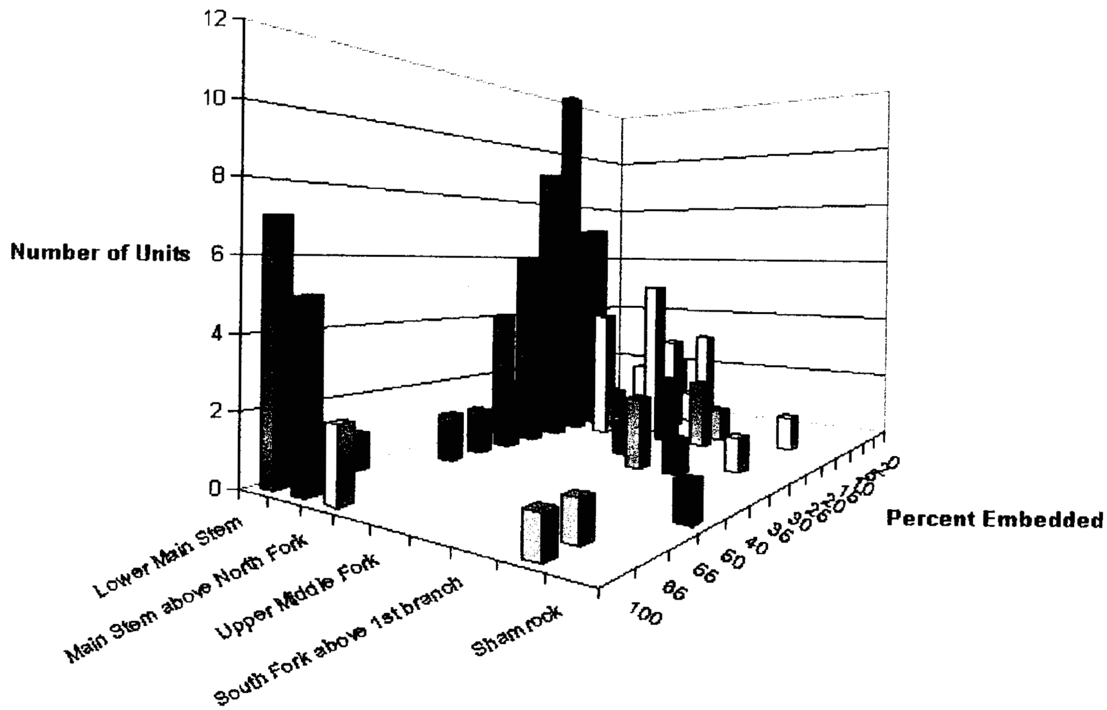

Figure 7. Pool Tail Embeddedness

Table 11. San Pedro Watershed Embeddedness (continued)

	Lower Main Stem	Upper Main Stem	Main Stem above North Fork	Middle Fork above South Fork	Upper Middle Fork	South Fork	South Fork above 1st branch	Sanchez Branch	Shamrock Branch
Spawning Gravel Embeddedness (%)	Number of Habitat Units								
0			1	6					
2				3					
5	6			5					
10	12	5	1	6	1		2	1	
15	5	2	3			1	1		
20	4		1	1			1		
25	1				2				
30							1		
50	1								
Areas with Spawning Gravel Surveyed	29	7	6	21	3	1	5	1	0
Spawning Gravel Area (square feet)	384	106	72	206	26	5	115	1.5	0
Spawning Area (square ft) per 100 ft	5.8	2.8	3.7	4.3	6.3	0.7	6.1	0.1	0.0

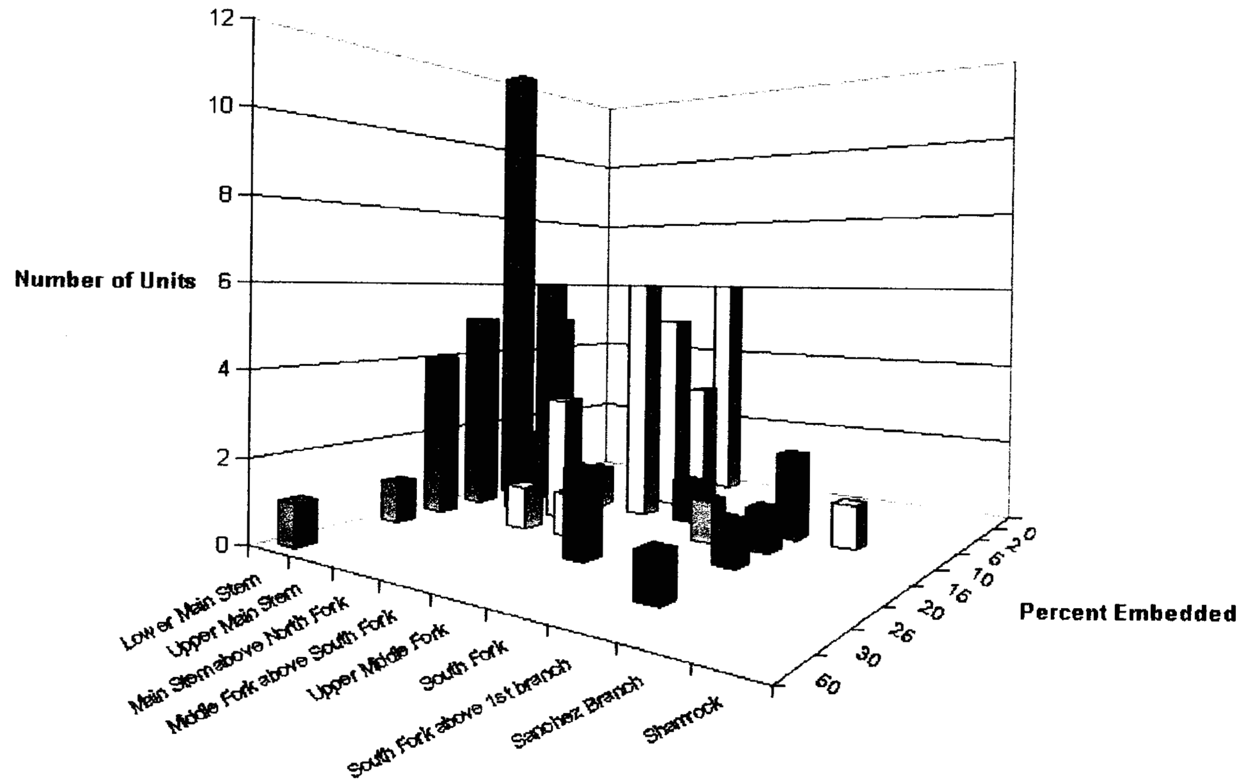

Figure 8. Spawning Gravel Embeddedness

Pool tail embeddedness is a measure of accumulation of fine sediments in a stream. The mainstem had a wide range of embeddedness estimates with the majority of units at 35% or less but several units at 100% due to extensive accumulation of sand in the pool tails (Figure 7, Table 11). The mainstem upstream of the North Fork had the lowest embeddedness with 80% of surveyed units having embeddedness estimates of 15% or less. The remaining 20% of units had pool tails composed of sand yielding embeddedness estimates of 100%. Embeddedness was also measured in areas considered to be ideal for spawning salmonids. Although many of these sites were in pool tails, estimates in these locations tended to be considerably lower than pool tails as a group (Figure 8, Table 11).

There are four potential migration obstacles in the mainstem of San Pedro Creek, each at a bridge crossing. The first, at Adobe Road is a 7.5 foot wide box culvert that has been retrofit with wood beams on the floor of the culvert to enhance fish passage (Figure 9). The Adobe Road culvert appears to be an obstacle to steelhead migration only at relatively low flow levels.

Figure 9. Adobe Road Culvert

The second mainstem obstacle, the Capistrano Road Bridge is likely a barrier to adult steelhead at most flow levels and may be a complete barrier for upstream migration of juvenile steelhead. Although the structure is fitted with two sections of Denil fish ladder with an intervening resting pool, the entrance to the ladder is perched approximately 4 feet above the water surface of the downstream pool (Figure 10). Although boulder weirs have been placed downstream of the ladder in an attempt to minimize this drop, there may still be very difficult access to the ladder at all but the highest flows. The straightened and concrete lined channel upstream from the ladder may also present difficult passage conditions at higher flows although sediment has collected in most of this channel providing a degree of roughness that resembles natural channel conditions.

Figure 10. Capistrano Road Fish Ladder

The third migration obstacle is formed by the Linda Mar Bridge. The culvert is approximately 76 feet long and 16.5 feet in width with an even concrete bottom. The culvert is slightly perched (about 0.5 feet) and the wide, flat floor would result in shallow flow depth at most lower flows (Figure 11). The 3% gradient is not consistent with National Marine Fisheries Service (NMFS) passage guidelines and may result in excessive flow velocity at higher flows. The Linda Mar Bridge was judged to be an obstacle to upstream migration at most flows for both adults and juveniles.

Figure 11. Linda Mar Bridge

The last migration obstacle on the mainstem is at Oddstad Bridge and is also judged to be a barrier to upstream migration of both adult and juvenile steelhead at most flows (Figure 12). The roadbed rests on a double concrete box culvert with each bore approximately 64 feet in length and 10 feet in width. The right bore has a lot of sediment accumulated in it and most flow is through the left bore. The culverts were perched by about 1 foot at the time of the survey and the gradient was measured at about 2%.

Figure 12. Oddstad Road Culvert

3.2 Middle Fork

Two sections of the Middle Fork were surveyed, the lower section from the South Fork confluence to the point where the stream branches, about 4,800 feet upstream (about 470 feet upstream from new bridge installation), and the upper section above this branch. In the vicinity of the branch, the

Middle Fork had become just a trickle of flow between pools with a wetted width of only about 2 feet and the channel was densely overgrown with willow, dogwood, and other shrubs. The southern branch was also just a trickle with little standing water (Figure 13). There were some debris jams in the lower part of the southern branch with cascades to about 2 feet high. Bankfull width in the southern branch was about 3 feet and no fish were seen. The southern branch provides little if any habitat for steelhead. Although the Middle Fork upstream of the southern branch was also very small, there were pockets of standing water and young-of-year steelhead/rainbow trout were present for at least 400 feet upstream of the southern branch. At that point the stream was becoming intermittent, was steeper, and had little habitat for fish. This was considered the upper limit for anadromous fish in the Middle Fork.

Figure 13. Middle Fork Southern Branch

The relatively small drainage area of the Middle Fork is reflected in the low discharge estimates at the time of the survey and low mean widths of 4.6 feet in the lower section and 3.5 feet in the upper section (Table 1). The lower section was primarily flatwater habitat (66% of the surveyed length), with lesser amounts of riffle (27%) and only a small amount of pool habitat (7% of the surveyed length) (Table 1, Figure 2). In the upper section riffles became the dominant habitat type (63% of the surveyed length) with flatwater second at 24% and pools making up 13% of the surveyed length.

The Middle Fork and upper Middle Fork were quite shallow (Table 2). The few pools in the Middle Fork all had mean depths of 1 foot or less (Figure 3) and all but a few had maximum depths of 1.5 feet or less (Figure 4).

In spite of the small size of the stream, visual observations indicated relatively high abundance of steelhead (Table 3). The frequency of visual counts in the lower reach was 4.2 fish per foot, the second highest observed frequency after the upper mainstem and well above the frequency observed in other tributaries. Even above the branch, steelhead were seen at a rate of nearly 2 per 100 feet. The majority of steelhead observed (about 98%) were young-of-year.

Shelter percent coverage was slightly greater in the Middle Fork than in the mainstem reaches, due primarily to the narrowness of the channel and thickness of overhanging vegetation (Table 6). The most frequent shelter components in the lower reach included substrate (present in 79% of units), small woody debris (62% of units), terrestrial vegetation (58% of units), and undercut bank (42 % of units) (Table 7). In terms of overall contribution to shelter, small woody debris, substrate, and undercut bank each comprised about a quarter while terrestrial vegetation accounted for 14% of the total (Table 7). Shelter components in the upper reach are similar except that terrestrial vegetation and large woody debris become more prevalent while substrate and small woody debris become less important.

The canopy was relatively dense in the Middle Fork, averaging 87% coverage in the lower reach and 90% in the upper reach (Table 8). The minimum canopy coverage in the lower reach was 55% but was 80% in the upper reach. Alder was the dominant species in the lower Middle Fork with willow the main subdominant although there was also a large grove of eucalyptus along the Middle Fork just upstream of the South Fork. The upper Middle Fork canopy was dominated by dense willow and dogwood.

Gravel was the most frequently encountered substrate in the Middle Fork, being dominant in 67%, and 78% of units in the lower and upper reaches, respectively (Table 9, Figure 6). The major subdominant size class in both reaches was small cobble. In riffle habitat types, gravel was dominant in 86% of lower reach units with small cobble dominant in the rest (Table 10). In the upper reach gravel and small cobble were each dominant in half the riffle units. Subdominant substrate types in the Middle Fork riffles included gravel, cobble, and boulder but no sand or finer size classes.

Pool tail embeddedness was generally very low in the Middle Fork between the South Fork and the first branch (Table 11, Figure 7). The highest embeddedness encountered in this reach was 15%. Upstream of the first branch, conditions were almost as good with 2 of the 3 pool units at 15% and one at 25%. Embeddedness estimates for potential spawning areas were generally lower than the pool tail estimates (Figure 8), with over 65% having embeddedness estimates of 5% or less.

In the Middle Fork, only one potential passage obstacle was identified. This was the culvert at a fire road/footpath crossing in the Park picnic area (Figure 14). The culvert is relatively short (38 feet), about 8 feet wide and has a gradient of about 2%. There is a 45° bend about half way through the culvert that would induce some variation in flow velocity and enhance passage potential. The culvert was perched by about 0.5 feet at the time of the survey. This culvert was judged to be a potential obstacle to adult steelhead at low flows only but is possibly a barrier to upstream migration of juvenile steelhead at most flows.

Figure 14. Lower Middle Fork Culvert

Further upstream in the Middle Fork (about 1 mile upstream from Oddstad Road) a new bridge had recently been placed across the stream and the channel had been re-contoured for about 70 feet downstream. At the time of the survey the recontoured channel was unconsolidated and had quite a high gradient. There appeared to be a potential for significant bed migration in this area that could potentially lead to future passage problems.

3.3 South Fork

Two reaches of the South Fork were surveyed. Dense brush obstructed the stream channel in many locations and only a portion of both reaches were sampled (Figure 15). The first reach extended from the confluence with the Middle Fork to the first main branch. The second reach was the east branch up past the North Coast County Water District diversion point and upstream for about 0.25

miles. The west branch was very small and had less than one tenth the flow in the east branch. It is not expected that the west branch would support steelhead and it was not surveyed. The South Fork had a relatively high level of flow at the time of the survey (Table 1). The watershed upstream the NCCWD diversion point is about 450 acres and is comparable in size to the Sanchez Branch (582 acres), Shamrock Branch (361 acres) and the Middle Fork upstream of the new bridge (554 acres) although it appears to produce a greater stream flow.

Figure 15. Lower South Fork

Surveyed reaches in the South Fork consisted primarily of flatwater and riffle type habitat (Table 1, Figure 2). The lower reach had few pools (7% of surveyed length) and the upper reach had only one pool. The pools had average depths up to 1.5 feet and maximum depths up to 2 feet (Table 2,

Figure 3). Pool spacing in the lower reach was slightly greater than the mainstem reaches but less than the lower Middle Fork reach. Pool spacing in the upper reach was the highest of any surveyed reach.

Although steelhead/rainbow trout were present in the South Fork, their abundance appeared extremely low based on visual counts (Table 3).

Shelter coverage was relatively high in both reaches (Table 6) and shelter complexity ratings were medium or high in most surveyed units. Frequency of occurrence was highest for small woody debris, surface turbulence, substrate, terrestrial vegetation, and undercut bank (Table 7), though, in terms of overall coverage, substrate, small woody debris, surface turbulence, and in the upper reach, terrestrial vegetation contributed to the greatest extent of shelter (Figure 5, Figure 15).

Canopy coverage was relatively high in both reaches, averaging 81% in the lower reach and 95% in the upper (Table 8). Dominant species included alder and dogwood with some willow in the lower reach and eucalyptus in both reaches.

Sand was the dominant substrate size class in 42% of habitat units in the lower reach but only 17% of units in the upper reach, where gravel became the most common dominant substrate (Table 9, Figure 6). Larger size classes, including cobble and boulder, were more prevalent as subdominant size classes in the South Fork than in the mainstem or middle fork. Riffle habitat was free of sand and silt in both reaches of the South Fork (Table 10). Embeddedness ratings were relatively low in both reaches for both pool tail areas and spawning sites (Table 11), though suitable spawning sites were very scarce, averaging 0.6 square feet per 100 feet of stream in the lower reach. Spawning sites were much more numerous in the upper reach, averaging 6.1 square feet per 100 feet, however this was the result of a large number of very small sites. Virtually all the spawning areas were upstream of the NCCWD diversion and were suitable for resident trout but too small to be used by steelhead. In the lower reach and in the upper reach downstream of the NCCWD diversion, total spawning sites were limited to a single 5-square foot area in each reach. A 5-square foot area would be near the minimum size needed by a steelhead.

One small potential obstacle was identified in the South Fork at a site that appeared to be the old diversion dam for the fish hatchery that was once present. This would probably be a barrier to adults only at low flows but may present an obstacle to upstream movement of juveniles over a wider range of flows. The site could be easily modified for enhanced passage. The stream in the vicinity of the NCCWD diversion is very steep (gradient 15%) with bedrock outcropping. The diversion itself is located at a bedrock outcrop/cascade that is an obstacle to fish migration.

3.4 Sanchez Branch

The Sanchez Branch has a relatively small drainage area of 582 acres (0.92 sq. mi.). The stream is small, with average wetted width of 4.7 feet at the time of the survey (Table 1, Figure 16). The habitat was primarily shallow riffle and flatwater habitat with maximum depth of 0.5 feet or less (Figure 2). Only four pools were identified in the 1692 foot length of Sanchez Branch surveyed (1 pool per 423 feet) and pool habitat represented only 5% of the survey length . The two largest and deepest pools were formed below culverts. Concrete rubble and a concrete retaining wall were factors in formation of the other two pools. The few pools present had good shelter characteristics, averaging 35% coverage of the unit and consisting of overhanging terrestrial vegetation, anthropogenic sources, small woody debris, substrate elements, undercut bank, and surface turbulence (Table 6, Figure 5). Flatwater was the dominant habitat type, making up 68% of the survey reach (Table 1). Flatwater habitat was generally shallow (less than 0.5 feet maximum depth) and had only moderate shelter coverage, averaging 21% in surveyed units (Table 6). Substrate was dominated by silt/clay (43% of surveyed units) and sand (28% of surveyed units) (Table 9). Silt/clay was subdominant in an additional 7% of surveyed units and sand was subdominant in 21% of units. The lower part of Sanchez Branch had a relatively steep gradient and a lot of concrete rubble in it that, in places, constricted the flow and formed potential low flow passage obstacles.

Figure 16. Lower Sanchez Branch

Two potential migration obstacles were identified on the Sanchez Branch. The first was judged to be a complete barrier to upstream migration for both adult and juvenile steelhead. It is located approximately 1,025 feet upstream from the confluence with the mainstem San Pedro Creek. At this location, the creek was placed in a 125-foot long culvert to enable construction of a parking lot for a church. The culvert is 6-foot diameter corrugated metal pipe (CMP), has a gradient of about 3%, and was perched 6.5 feet above the downstream water surface at the time of the survey. A second culvert about 500 feet upstream was a 16-foot long, 3 foot by 3 foot rectangular concrete culvert with a gradient of about 12%. There was no obvious purpose for this culvert, though a relatively clear but vegetated grade existed above. It was judged to be a barrier to upstream migration of adult steelhead under most flow levels and a complete barrier to upstream movement of juveniles. Potential for remediation (i.e., ease of removal) was judged to be low for the first obstacle but high for the second obstacle. Obviously, removing the first barrier is essential for any benefit from removing the others upstream.

In spite of its small size and degraded habitat conditions, Sanchez Branch did have some trout in it (Table 3). All trout observed were less than 4 inches in length. These fish, though present in low abundance, were observed both downstream and upstream of the first perched culvert. This would indicate that there is some production by resident trout in Sanchez Branch, that steelhead may be able to pass the perched culvert under some flow conditions, or that they were artificially introduced to the creek.

3.5 Shamrock Branch

The Shamrock Branch has a very small drainage area of 361 acres (0.56 sq. mi.). Early maps of the area, published in 1866 and 1868, do not indicate a permanent stream in this area although other tributaries are shown (Collins et al. 2001). A 1928 aerial photograph of the area shows a straightened channel indicative of a drainage ditch and associated vegetation. The side valley appears to be open grassland in the 1928 photo and remains so in the present.

The Shamrock Branch enters the mainstem about 200 feet upstream of Peralta Road. At the confluence there was just a trickle of flow and the wetted channel width was only 1-2 feet (Table 1). Estimated discharge was 0.1 to 0.2 cfs at the time of the survey. About 75 feet upstream from the mainstem the Shamrock Branch emerges from a 6 foot wide by 4 foot high oval culvert. This culvert runs under a residential neighborhood and the Linda Mar School grounds for a total distance estimated at 1,000 feet. This is the straight line distance on a USGS topographic map from the culvert exit point to the point where the channel goes into the culvert above Linda Mar School at the Shamrock Kennels access road. Conditions in the culvert were not evaluated in terms of gradient, internal elevation drops or other obstacles. Based on its length, it is highly unlikely that steelhead would pass through this culvert.

The habitat downstream of the culvert consisted mostly of low gradient to high gradient riffle with a maximum depth of 0.1 to 0.2 feet (Figure 2). There was one ten-foot long pool section with a mean depth of 0.5 feet and a maximum depth of 1.0 foot. The pool had a substrate dominated by silt (50%) with small cobble as the subdominant (20%). Shelter in the pool was provided by undercut bank and overhanging terrestrial vegetation and influenced about 35% of the unit. The riffles had essentially no shelter. Canopy in this section was 20 to 40%. The habitat was highly degraded with active erosion from a garden on the west bank, and concrete debris in the channel. No fish were seen and the stream appeared to have negligible potential to support any life-stage of steelhead.

Upstream of Linda Mar School, the stream channel is extremely small and overgrown by dense growths of willow, blackberry and other riparian species (Figure 17). There was little to no access

to the creek and detailed habitat mapping was not conducted. The watershed outside the immediate stream channel consists mostly of grassy fields on the valley floor and scrub on the side slopes. The valley floor appears to be rather intensively used for livestock and equestrian activities. There is a low earthen dam in the upper part of the watershed but the pond held no water at the time of the survey.

The Shamrock Branch appears to have little or no potential to support steelhead/rainbow trout. Nevertheless, activities in the watershed have the potential to contribute to water quality, streamflow, and sediment conditions in the mainstem and in that way, conditions in this sub-watershed are important to maintenance of steelhead/rainbow trout populations in the lower mainstem.

Figure 17. Shamrock Branch above Linda Mar School

4.0 Limiting Factor Assessment

Suitable habitat for steelhead exists primarily in the Mainstem and Middle Fork. Based on substrate composition and embeddedness estimates, suitable habitat for spawning is located throughout the Mainstem and Middle Fork but the best quality spawning habitat appears to be in the Middle Fork. This is supported by visual observation of numerous young-of-year steelhead/rainbow trout in the Middle Fork. These observations also suggest that the Middle Fork provides good conditions for rearing steelhead in their first year of life. Based on the streams small size however, and the low frequency and shallow depth of pools, it is expected that many of these fish would move to lower reaches after their first year of life.

Based on the frequency, depth conditions, and cover characteristics in pools and flatwater habitats, the Mainstem provides the best conditions for rearing steelhead to smolt size and for supporting non-anadromous life histories. Steelhead using the Mainstem are more vulnerable to potential water quality degradation, siltation, sedimentation, and disturbance than those in the Middle Fork. Successful spawning in the mainstem may be limited by a combination of relatively small gravel substrate and high peak flow, resulting in damage to eggs and fry from substrate mobilization during high flows. This emphasizes the importance of the Middle Fork as a potential refuge area, from which steelhead could potentially repopulate the lower watershed following an extreme event. Steelhead spawning in the Middle Fork have the potential to saturate the available habitat with fry and produce a surplus that would eventually take up residence in downstream reaches. On the other hand, most fish produced in the Middle Fork likely require a period of residence in the larger mainstem habitats to reach sufficient size for smoltification.

Common factors that limit production of steelhead and salmon in Central California coastal streams typically include migration obstacles that limit or preclude access to suitable habitat; excessive stream temperature that eliminates rearing potential or truncates migration periods; seasonal elimination of rearing or migration habitat through loss or reduction of stream flow during key periods; reduction of rearing capacity do to lack of instream cover; reduction in recruitment and rearing success due to excessive fine sediment accumulations; excessive mortality due to toxic water quality episodes (gasoline spills, waste disposal, swimming pool discharges, etc.);diminished spawning success düe to human disturbance; and reduction in spawning populations due to excessive legal or illegal harvest. The potential for these factors to influence steelhead in the San Pedro watershed is explored in the following sections.

4.1 Migration Obstacles

Migration obstacles are a significant limiting factor in the San Pedro watershed. The four mainstem obstacles and the obstacle in the Middle Fork, all limit to varying degrees the ability of adult steelhead to access spawning areas and the free movement of juvenile steelhead within rearing areas. None of these obstacles, described in preceding sections, are likely to form complete barriers to migration of steelhead, rather they act by reducing the periods of time when passage is possible. All five obstacles are at stream crossings and all are located within potential steelhead spawning and rearing areas. Obstructing the migration or rearing of steelhead is considered a take under the Federal Endangered Species Act and is thereby a violation of Federal law. The National Marine Fisheries Service has adopted guidelines for salmonid passage at stream crossings to aid upstream and downstream passage of migrating salmonids (NMFS 2000).

Optimum passage at road crossings is obtained when depth of flow and velocity conditions are comparable to natural stream conditions. This is best achieved by a full-span bridge, bottomless arch or embedded culvert, or a fishway. In spawning areas, NMFS guidelines call for full span bridges or embedded culvert designs as the only acceptable application. A reconnaissance level evaluation of each crossing was conducted during habitat surveys. A more complete evaluation, including hydraulic simulation, should be undertaken to determine whether each obstacle is in compliance with NMFS guidelines and the frequency and duration of acceptable passage conditions.

The Adobe Road culvert is approximately 50 feet in length and has a gradient greater than 0.5%. Under these conditions guidelines call for minimum depth of flow of 12 inches during adult steelhead passage periods and 6 inches during juvenile passage periods. Average velocity should be less than 6.0 feet per second (fps) for adults and less than 1.0 fps for juveniles. The Adobe Road culvert is perched by approximately 1 foot, which would be acceptable for adult passage provided that water depth and velocity in the culvert are satisfactory and that there is a pool with minimum depth of 2 feet immediately below the culvert outfall. Under higher flows expected during adult migration periods, the jump height would be reduced and the pool depth increased. Additional backwatering during low flow periods using placement of downstream hydraulic controls could improve passage potential for juvenile steelhead.

The Capistrano Road fish ladder likely does not meet the 1 foot jump height maximum recommended for adult steelhead at all flows that might be used by migrating adults. This would restrict migration to higher flow periods, possibly delay fish downstream of the ladder entrance, enhance the potential for poaching, and result in displacement of spawning from upstream reaches to reaches downstream of the ladder. It is likely that, at minimum, an extension of the ladder entrance would be required to meet passage guidelines. The fishway should also be evaluated to determine whether it meets guidelines for passage of juvenile steelhead. The concrete lined channel upstream of the fishway should be evaluated to determine the range of flows under which it meets depth and velocity criteria for both adult and juvenile steelhead.

The wide, flat floor of the Linda Mar Bridge arch culvert is likely to severely restrict the period of time when depth and velocity criteria are met for either adult or juvenile steelhead passage. This should be evaluated with hydraulic and hydrologic modeling. Backwatering and/or retrofit with baffles or other devices may minimize this problem.

The Oddstad Bridge culvert is not likely to meet depth and velocity conditions recommended for adult or juvenile steelhead passage during all periods when fish may be migrating. This should be further evaluated to determine the degree of passage obstruction relative to the other obstacles. Critical features include the width (20 feet including both bores), gradient (approximately 2%), and jump at the downstream side. This obstacle is relatively high in the watershed and, with less contributing watershed area, will not experience flows as high as those occurring at the lower migration obstacles.

Although the long culvert in the Shamrock Branch under the Linda Mar school is a migration obstacle, it is probably not a significant limiting factor for steelhead since there is little if any habitat in the watershed. Similarly, the major culvert in Sanchez Branch is a total barrier but is also probably not a significant limiting factor for steelhead since there is relatively little habitat upstream and the habitat is of low quality.

4.2 Temperature

Matuk (2001) collected some temperature grab samples in the watershed during 2000. Although it is difficult to draw firm conclusions about fisheries habitat from temperature grab samples, the temperature sampling reported by Matuk indicates that relatively cool temperatures may occur throughout the year. Since only mean values are presented it is not possible to identify potentially excessive daily excursions into unfavorable ranges. A more intense sampling program involving automated data recorders to record hourly values can be accomplished easily and inexpensively and would be desirable to fully evaluate temperature conditions for steelhead. In particular, more data in the tributaries would be useful. The existing data indicate there may be some thermal loading from the North Fork that could be problematic, particularly during the July-August period. Based on the existing information, temperature conditions appear not to be a factor limiting steelhead production in the watershed.

4.3 Stream Flow

Natural low stream flow levels in the small sub-watersheds limit steelhead production in the tributaries. The South Fork may be an exception in that it appears to have relatively high flows through the summer and may contribute a disproportionate share to summer streamflow in the Mainstem. A diversion operated by the North Coast County Water District has been operational at times in the past and has the potential to influence habitat conditions below the diversion. During the period 1968-1973 the project diverted throughout the year and took essentially all the available water in the South Fork at the diversion point. After this period, steelhead populations in San Pedro Creek appeared to have similar abundance and growth rates as in other comparable steelhead streams (Hanson et al.1975). The North Coast County Water District also has a diversion right on the Middle Fork that allows diversion of 1.5 cfs from December through May and 0.2 cfs during the summer (Hanson et al. 1975). The diversion was initiated in 1973 but current status of operations is unknown. Diversion pumps were noted during habitat surveys though they did not appear operational. The degree of riparian diversion from the Mainstem is unknown but several pump installations were noted during the habitat assessment.

Diversion of stream flow at current levels does not appear to be problematic but increased diversions have the potential to further limit steelhead populations in the watershed.

4.4 Rearing Capacity

Habitat surveys indicated that shelter conditions in those reaches that are suitable for steelhead (primarily in the Mainstem and Middle Fork) have shelter conditions that are consistent with good steelhead production in comparable streams. Pool habitats are reasonably frequent and the pools present have depth and shelter characteristics generally conducive to good steelhead production. Although steelhead population assessment was not conducted as part of this survey, visual observations and results of previous surveys (Anderson 1974, Sullivan 1990a, 1990b) indicate that production of steelhead in San Pedro Creek is similar to other comparable streams in the region. Anderson (1974) measured rearing densities by electrofishing at several sites and found densities of 64-186 steelhead/100 feet in the Mainstem, 221 /100 ft just downstream of the South Fork confluence, 60 /100 ft in the Middle Fork, and 55-178 in the South Fork. It would be of interest to compare these estimates with current density. Visual observations indicate much fewer fish in the South Fork and downstream of the South Fork confluence relative to other parts of the

Mainstem and Middle Fork. This may be real or may be related to bias involved with visual estimates.

4.5 Sediment

Substrate conditions in the San Pedro Creek are generally compatible with requirements of steelhead for successful spawning and rearing. However, any watershed that has the level of human activity and development present in the San Pedro watershed is expected to have elevated mobilization of sediment and increased fine sediment loads in the streams. During habitat surveys, many locations were observed where some type of bank protection had been installed, particularly in the mainstem. As described by Collins et al. (2001), many of these projects reduce bank erosion and sediment mobilization at the project site but may induce further erosion at adjoining sites.

Existing sediment accumulations in the substrate may somewhat limit steelhead productivity and any reduction in sediment loading would likely have some benefit to steelhead populations. Any increase in sediment loading has the potential to reduce steelhead productivity and, in the worst case, could induce a threshold response resulting in dramatic declines in the capacity of the watershed to support steelhead. Development of sediment control programs and projects should be a high priority for ensuring continued health of steelhead populations.

4.6 Water Quality

Water quality sampling was conducted in the watershed during 2000 (Matuk 2001) for a number of parameters. Sampling involved collection of grab samples during four periods in late January to February, late April to late May, mid-July to mid-August, and November. Although sampling frequency and intensity was not sufficient to capture infrequent or pulse events, the sampling indicates that most parameters are within limits that would not be problematic for steelhead populations.

Turbidity and suspended solids data are very useful for evaluating habitat conditions for steelhead. Turbidity data reported by Matuk indicates relatively low turbidity during the April-November period. Since turbidity should not fluctuate greatly during the dry season, grab samples can probably be reasonably interpreted to indicate satisfactory conditions for salmonids. Results of grab samples reported by Matuk during the January to February period are more difficult to interpret. Since turbidity and suspended sediment are highly influenced by runoff events, isolated grab samples do not provide good information to evaluate habitat conditions for salmonids. Sampling has to be of sufficient frequency and intensity to determine not only the peak concentrations but the time duration of different concentrations and the frequency of different levels of events. Of particular interest is the low level of turbidity reported by Matuk for the North Fork in January and February, the season when turbidity is expected to be higher due to increased runoff. Observations during October of 2001 by HES for the current study indicated much higher levels of turbidity in the North Fork than in the Middle Fork at the junction with the North Fork. The differences indicate intermittent or episodic seasonal effects that may be missed in isolated grab samples.

Also of interest in Matuk's report is that certain parameters were at elevated levels in the North Fork compared with the rest of the watershed. Measurements for alkalinity, hardness, electrical conductivity, nitrate, phosphorus, and silver were consistently higher in the North Fork than other sampling sites. In addition, the North Fork was the only location where there were detectable levels of ammonia, and zinc. The North Fork also had the highest levels of total coliforms of any site and significantly higher levels than other sites during the April-May and July-August sampling periods. Although most of the parameter values occurred at levels below applicable regulatory criteria, the results point to the North Fork as a source of water quality degradation with the potential to impair conditions for steelhead in all downstream reaches.

4.7 Disturbance

The mainstem of San Pedro Creek has banks that are largely in private ownership and are densely occupied by abundant humanity. Hundreds of private landowners, their families, and guests have unrestricted access to sections of the stream that support spawning and rearing of steelhead. The stream is small enough that both adult and juvenile steelhead are vulnerable to disturbance that may interrupt feeding or spawning, damage eggs and fry in redds, or otherwise cause harm. Observations during the habitat assessment indicate that, with a few exceptions, few of these neighbors actually frequent the creek. There are several locations where bridges cross the creek, and such points present traditional access points to a stream. On San Pedro Creek, again with a few exceptions, most of these potential entry points are well-fenced and do not appear to be much used. Considering the proximity of such large numbers of people it is fortunate for steelhead that the creek does not get more visitation than it does. Although these forms of human disturbance do not appear to substantially limit steelhead in San Pedro Creek at the present time, the potential is certainly there.

4.8 Exploitation

Existing fishing regulations allow fishing for steelhead in San Pedro Creek west of Highway 1 between November 16 and February 28. Fishing is restricted to Wednesdays, Saturdays, Sundays, legal holidays, and the season opening and closing days. Only barbless hooks may be used. The rest of the stream, upstream of Highway 1, is closed to fishing all year. The level of angler use, legal or illegal, is not consistently monitored and is unknown. Since the stream is small and not as well known as some of the larger coastal streams, it is likely that only local sportsmen would fish it. Although the habitat survey did not specifically address this issue, nothing was encountered during the habitat survey that would indicate high levels of legal or illegal fishing.

5.0 Recommendations

The most significant factors limiting steelhead in the San Pedro watershed or with high potential to do so include fish passage at Mainstem road crossings, low base flows, mobilization and accumulation of fine sediments in the Mainstem, deterioration of water quality, disturbance, and exploitation. In addition to impacts on steelhead biology, some of these factors present issues of regulatory significance in terms of their potential to result in "take" under the Endangered Species Act. Although not an exhaustive listing, the following actions could reduce the effect or potential effect of these factors:

Undertake informational activities such as workshops for riparian landowners and city planners regarding alternatives to traditional slope stabilization methods such as bio-technical alternatives for new projects or as old projects fail and bank stabilization is replaced. The City, in its capacity to permit these projects, should be familiar with and in compliance with NMFS guidelines.

Several road crossings present potential passage obstacles. These should be evaluated to determine under what flow conditions passage guidelines are met and how often those conditions are expected to occur at each site. This will enable prioritization of enhancement projects to target those with the shortest passable periods first.

Evaluate structures at Capistrano Bridge and modify to enhance passage. This could include adding a lower ladder section to eliminate the existing perched ladder entrance; evaluating the need for replacing the Denil sections with a pool and weir type ladder; and evaluating whether passage could be improved through the 600-foot concrete channel upstream of the ladder by retrofitting to provide increased bed roughness and/or velocity breaks.

Evaluate Linda Mar bridge relative to NMFS passage guidelines and modify to enhance passage conditions. This could involve placement of rock weirs or other hydraulic control structures downstream of the bridge to "backwater" the culvert and/or retrofitting the floor of the culvert to provide velocity breaks and concentrate flows for low flow passage.

Evaluate Oddstad bridge relative to passage guidelines and enhance passage conditions. This could be accomplished by the same approach as recommended for the Linda Mar bridge.

Replace the culvert in the Middle Fork with a full span bridge.

Monitor the new bridge installation in the Middle Fork (1 mile upstream from Oddstad Road) to identify and remedy any future bed migration.

Natural low stream flow levels in the small sub-watersheds limit steelhead production, particularly in the tributaries. If diversion levels are increased there is a potential to further limit steelhead populations in the watershed.

Although the North Fork, Shamrock Branch, and Sanchez Branch are not considered to have significant potential to support steelhead, these watersheds contribute to water quality, sediment, and flow conditions in the Mainstem and thereby have significant potential to impact steelhead populations. Projects to improve water quality, minimize mobilization of sediment, reduce peak flows, and enhance baseflows should be undertaken in these watersheds to benefit steelhead using the Mainstem.

Many sections of the Mainstem are somewhat buffered from surrounding residential areas by steep banks, thick riparian vegetation, and fences. In some locations, there are no visual indications that the stream is surrounded by a developed area (Figure 18). There are a few locations, such as along the grounds of Sanchez School and the south bank downstream of Peralta Road that are still somewhat open. These conditions should be maintained and enhanced wherever possible through agreements, easements, and acquisitions. In the past, development policies and interests have resulted in developed areas encroaching closely to the creek without full recognition of the potential amenities of stream corridors in their natural state and the liabilities inherent in placing development too close to their banks. This condition should be corrected wherever an opportunity presents itself.

Figure 18. Lower Mainstem San Pedro Creek

6.0 References

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APPENDIX A

Steelhead/Rainbow Trout Life-History Characteristics and Habitat Requirements

Steelhead/rainbow trout have a very flexible life history. All *Oncorhynchus mykiss* (*O. mykiss*) hatch in the gravel substrate of coldwater streams. After a period of two to three weeks the young fry begin to emerge from the gravel and start feeding in the stream. Some begin to disperse downstream in the months following their emergence but most continue to rear in the stream. Following a rearing period of at least one year, juveniles (parr) may follow a variety of life-history patterns including residents (non-migratory) at one extreme and individuals that migrate to the open ocean (anadromous) at another extreme. Intermediate life-history patterns include fish that migrate within the stream (potamodromous), fish that migrate only as far as estuarine habitat, and fish that migrate to near-shore ocean areas These life-history patterns do not appear to be genetically distinct, and have been observed interbreeding (Shapovalov and Taft 1954).

Rainbow trout that migrate to the ocean (anadromous) undergo physiological changes in the process of smoltification that allow them to adapt to seawater. These fish, commonly referred to as steelhead, spend a variable amount of time in the ocean, typically one to two years, grow rapidly and return to spawn, generally in the stream where they hatched. Steelhead are unusual among the other Pacific salmonids in that they do not all die after spawning. Some return immediately to the ocean, others return after holding for a period in freshwater. Some rainbow trout within any given stream, and the proportion may vary considerably depending on local circumstances, do not migrate to the sea. These fish reach sexual maturity and spawn without entering the ocean and are often known as resident or stream rainbow trout. They mature at smaller sizes than sea-run steelhead and produce fewer eggs. There are a number of documented life-history strategies that are intermediate between resident populations and fully anadromous populations.

Within a given stream, some *O. mykiss* do not migrate to the sea, and the proportion may vary considerably depending on local circumstances. These fish reach sexual maturity and spawn without entering the ocean and are often known as resident or stream rainbow trout. There are selective advantages to both anadromous and resident strategies (Cramer et al. 1995). Anadromous fish grow faster and reach a larger size thereby gaining a potential to produce more offspring than resident fish. At the same time, however, migratory fish are exposed to many sources of mortality and there is a risk that conditions may become unsuitable for migration, particularly in California where fluctuating climatic conditions can result in long periods when streams have tenuous connection to the ocean. In California, many streams support both resident and anadromous forms with no observable genetic differentiation. During extended drought periods it is possible for populations to sustain themselves through resident spawning and then revert to an anadromous life history when suitable conditions return.

Steelhead/rainbow trout habitat requirements are associated with distinct life history stages including migration from the ocean to inland reproductive and rearing habitats, spawning and egg incubation, rearing, and seaward migration of smolts and spawned adults. Habitat requirements and life-history timing can vary widely over the steelhead's natural range (Barnhart 1986; Pearcy 1992; Busby et al. 1996). Some of the best information on steelhead life history comes from a multi-year study in Waddell Creek in the Santa Cruz mountains (Shapovalov and Taft 1954)

In-migration of adult steelhead. Steelhead along the Central California coast enter freshwater to spawn when winter rains have been sufficient to raise streamflows and breach sandbars that form at the mouths of many streams during the summer. Increased streamflow during runoff events also appears to provide cues that stimulate migration and allows better conditions for fish to pass obstructions and shallow areas on their way upstream. The season for upstream migration of adults lasts from late-October through the end of May but typically the bulk of migration (over 95% in Waddell Creek) occurs between mid-December and mid-April. Steelhead have strong swimming and leaping abilities that allow them to ascend streams into small tributary and headwater reaches. Steelhead can swim at rates of up to 4 feet per second for extended periods of time and can achieve burst speeds of 12 feet per second or more during passage through difficult areas (Bell 1986). Given satisfactory conditions, a conservative estimate of steelhead leaping ability is a height of 6 to 9 feet (Bjornn and Reiser 1991), although other estimates range to as high as 15 feet (McEwan 1999)

Spawning and egg incubation. Steelhead and rainbow trout select spawning sites with gravel substrate and with sufficient flow velocity to maintain circulation through the gravel and provide a clean, well-oxygenated environment for incubating eggs. Preferred gravel substrate is in the range of 0.25 to 2.5 inches in diameter and flow velocity is in the range of 1-3 feet per second. Steelhead will use substrate with larger gravel (up to 4 inches) than resident trout. Typically, sites with preferred features for spawning occur most frequently in the pool tail/riffle head areas where flow accelerates out of the pool into the higher gradient section below. In such an area, the female steelhead will create a pit, or redd, by undulating her tail and body against the substrate. This process also disturbs fine sediment in the substrate and lifts it into the current to be carried downstream, cleaning the nest area. Survival of fertilized eggs through hatching and emergence from the gravel is most often limited by severe changes in flow that can dislodge eggs from the substrate, result in sedimentation, or de-water incubation sites.

Rearing. After emergence from the gravel, trout fry inhabit low velocity areas along the stream margins. As they feed and grow they gradually move to deeper and faster water. Trout of 4-6 inches (generally in their second year of life) may be commonly found in riffle habitat, particularly in warmer streams. Trout larger than 6 inches are more often found in deeper waters where low velocity areas are in close proximity to higher velocity areas and cover is provided by boulders, undercut banks, logs, or other objects. Heads of pools generally provide classic conditions for older trout. Trout, particularly coastal steelhead/rainbow trout, can inhabit quite small streams. Often habitat for older trout may be far more limiting than habitat for younger fish. The critical period is during base flow conditions that generally occur between May and October in Central California. Streamflow can drop to very low levels with loss of depth and velocity in riffle and run habitats, or in the extreme, only isolated pools with intervening dry sections of stream.

Although standard definitions of good trout rearing habitat often include conditions such as baseflows of at least 25 to 50% of the average annual daily flow, 1:1 riffle to pool ratios, and depths of a foot or more, these conditions may not always be achieved in Central California streams that still support relatively good steelhead/rainbow trout populations. Steelhead/rainbow trout populations in Central California can occur in streams with relatively low baseflow and in streams varying widely in terms of standard evaluation parameters such as pool:riffle ratio and mean depth. Often, local populations thrive under conditions that may depart widely from species norms (Behnke 1992). Steelhead respond to stream conditions that limit habitat for older trout by leaving the small streams to complete the maturation process in the more accommodating ocean environment.

Temperature is an important factor for steelhead/rainbow trout, particularly during the over-summer rearing period. The influence of water temperature on steelhead and other salmonids has been well studied and the influence on individual trout populations is complicated by a number of factors such as local adaptations, behavioral responses, other habitat conditions, daily and annual thermal cycles, and food availability. The most definitive temperature tolerance studies have been conducted in laboratory settings where experimental conditions have been highly controlled and fish were exposed to constant temperatures (Brett 1952; Brett et al. 1982). Upper lethal temperature for Pacific salmonids is in the range of 75-77°F (24-25°C) for continuous long-term exposure. Elevated temperature below the lethal threshold can have indirect influence on survival due to depression of growth rate, increased susceptibility to disease, and lowered ability to evade predators. In some studies, steelhead have exhibited decreased migratory behavior and decreased seawater survival at temperature in excess of 55°F (13°C) (Zaugg and Wagner 1973; Adams et al. 1975).

Smolt Out-migration. Behavior of steelhead/rainbow trout in Waddell Creek is probably typical for most Central California populations. Trout of various ages migrated out of Waddell Creek in all months of the year but the majority migrated in April, May and June. Downstream migration of young-of-year fish (less than a year old) extended from late-April through the following spring, however this movement may have been just dispersal to downstream rearing areas and not a true seaward migration. Downstream migration of 1-year-old fish was from April through late June and 2-year-old fish from March through late May.

Out-migration of adults. Steelhead that survive spawning return downstream to re-enter the ocean. As many as 20% of adult spawners may be repeat spawners and some fish may return to spawn up to 3 or 4 times (Shapovalov and Taft 1954). In some streams fish return downstream immediately after spawning while in others they may remain for a period up to several months. After spawning, these fish do not typically resume feeding while in freshwater. Fish that remain in the stream for any period of time generally reside in deeper pools. In Waddell Creek the bulk of adults returned downstream from April through June.

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